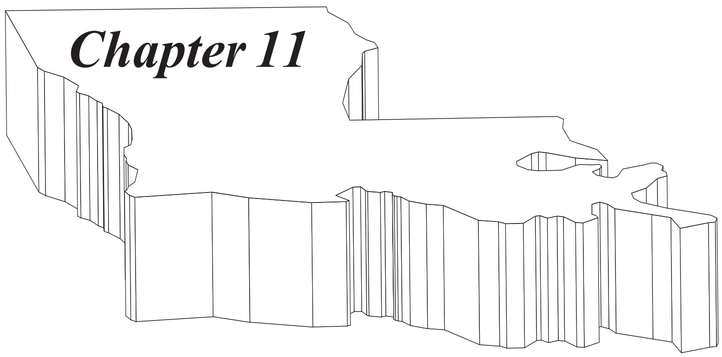


Chapter 11

Natural Cooling

*L*ouisiana's hot, humid summers drive most people indoors to air conditioned comfort — comfort that is paid for by high monthly cooling bills. Homeowners that use energy efficient options—properly installed insulation and HVAC systems with aggressive air sealing and duct sealing—will have lower summer cooling bills.

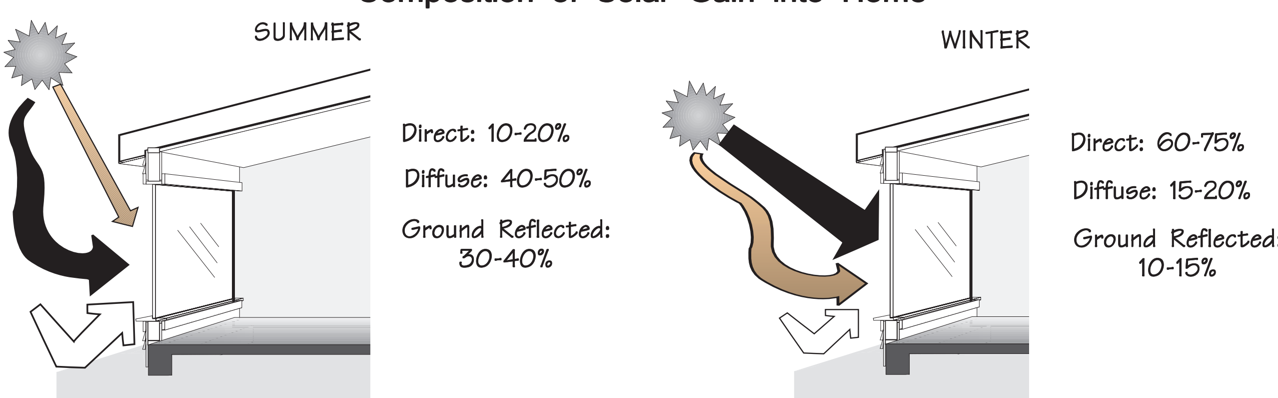
Design ideas known as natural cooling measures can further reduce the air conditioning needs of any house. Natural cooling guidelines are especially important for passive solar homes because their large expanses of south-facing glass can cause overheating if unprotected in summer.

In Louisiana, summer discomfort is caused by humidity as well as heat. Natural cooling techniques and new approaches designed to reduce humidity levels can promote comfort on moderately warm days. However, even in well designed homes, air conditioning will be needed to maintain comfort on the hottest days. Regardless, natural cooling techniques will continue to save money by reducing the amount of air conditioning required.

Window Shading Options

The effectiveness of different window shading options depends on the composition of the incoming sunlight. Sunlight reaches the home in three forms: *direct, diffuse*, and *ground reflected*. On a clear day, most sunlight is direct, traveling as a beam from the sun to a home's windows without obstruction. Figure 11-1 shows that most of the direct sunlight striking windows in winter is transmitted. However, in summer, sunlight hits south

Figure 11-1
Composition of Solar Gain into Home



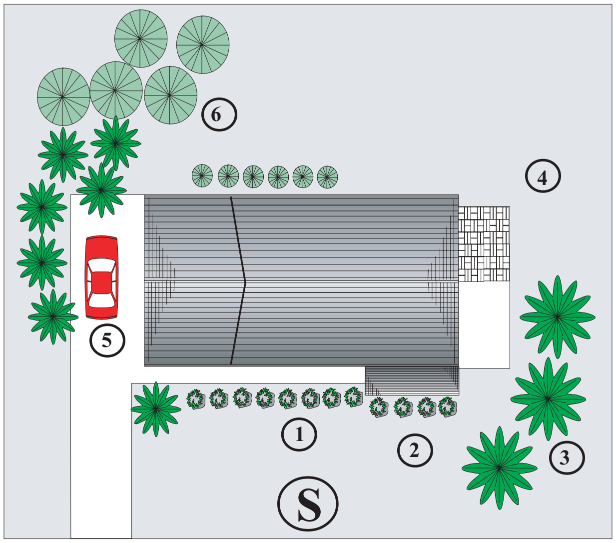


Figure 11-2
Landscaping Guidelines

1. Major glass areas are oriented within 20 degrees of south and have overhangs for summer shading.
2. Ground cover reduces reflected sunlight.
3. Deciduous trees shade east, west, southeast, and southwest sides in summer.
4. Trellis with deciduous vine shades east wall.
5. Garage on west blocks summer sun and winter winds.
6. Windbreak of evergreen trees and shrubs to the north buffers winter winds.

windows at a steep angle, and much of the direct sunlight is reflected.

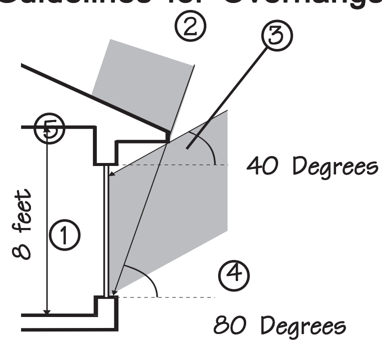
The majority of the sunlight entering south-facing windows in the summer is either diffuse — bounced between the particles in the sky until it arrives as a bright haze — or is reflected off the ground. In developing a strategy for effectively shading windows, consider both direct and indirect sources of sunlight. Overhangs, long thought to be totally effective for shading south-facing windows, are best at blocking direct sunlight and are therefore only a partial solution. Other shading options include landscaping and trees, awnings, exterior and interior shades, and window films.

Landscaping and Trees

According to the U.S. Department of Energy report, "Landscaping for Energy Efficiency" (DOE/GO-10095-046), careful landscaping can save up to 25% of a household's energy consumption for heating and cooling. Trees and vines are very effective means of shading in the summer months as well as providing protection from cool winter winds. In addition to contributing shade, landscape features combined with a lawn or other ground cover can reduce air temperatures as much as 9°F in the surrounding area when water evaporates from vegetation and cools the surrounding air.

Louisiana's abundant trees are wonderful for natural shading and cooling. However, as shown in Figure 11-2, in the northern areas of the state they must be located so as to provide shade in summer and not block the winter sun coming from the south. Even deciduous trees that lose their leaves during cold weather block some

Figure 11-3
Guidelines for Overhangs



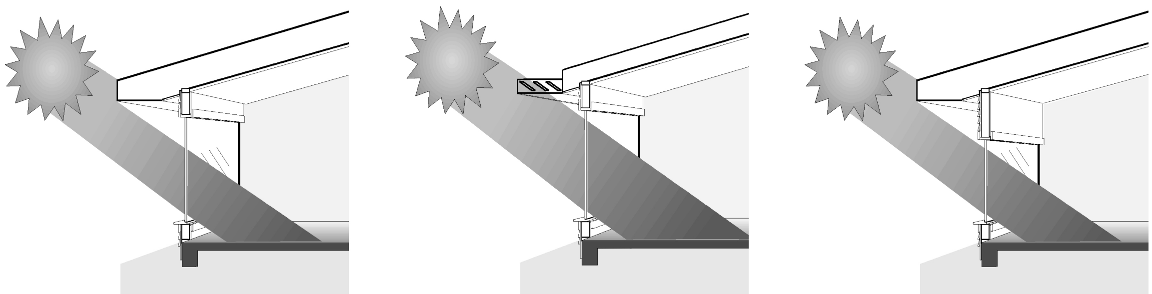
Size south overhangs using the diagram above and these rules:

1. Draw the wall to be shaded to scale.
2. Draw the summer sun angle upward from the bottom of the glazing.
3. Extend the overhang until it intersects the summer sun angle line.
4. Draw the line at the winter sun angle from the bottom edge of the overhang to the wall.
5. Use a solid wall above the line where the winter sun hits. The portion of the wall below that line should be glazed.

Summer and Winter Sun Angles
(Degrees from horizon at noon)

	July 21	January 21
Alexandria	78.5	38.5
Baton Rouge	79.5	39.5
New Orleans	80.0	40.0
Shreveport	77.5	37.5

Figure 11-4
Overhang Design Strategies



winter sunlight — a few bare trees can block over 50 percent of the available solar energy.

Overhangs

Overhangs shade direct sunlight on windows facing within about 30 degrees of south. Overhangs on east and west windows are ineffective unless they extend out horizontally as far as the window is high.

Overhangs above south-facing windows should provide complete shade for the glazing in midsummer — around July 21 — yet still allow access to winter sunlight. For a standard 8-foot wall with windows, the overhang should be 2 to 2 1/2 feet in length. The window should not extend all the way up to the bottom of the overhang; otherwise, the top of the glazing will be shaded in winter. Figure 11-3 on Page 160 shows how to size overhangs for south-facing windows.

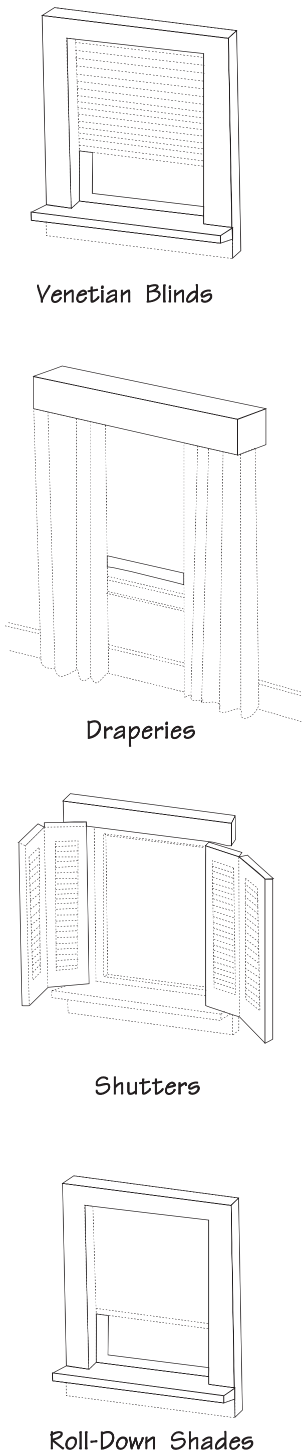
Retractable awnings allow full winter sunlight, yet provide effective summer shading. They should have open sides or vents to prevent accumulation of hot air underneath. Awnings may be more expensive than other shading options, but they serve also as an attractive design feature.

Table 11-1
Economic Analysis of Shading Measures*

Type of Treatment	Energy Savings ($/yr)	Additional Installation Costs ($)	Rate of Return (%)	Extra Annual Mortgage Costs ($)
Some shading (1-foot overhang)	68	300	25%	24
Substantial shading (2-foot overhang, effective blinds)	134	600	24%	48
Complete shading (louvered shutters)	202	900	24%	72

* Compared to a 2,000-square-foot home with no shading measures in Baton Rouge, with 75 square feet of windows on each exposure of the home.

Figure 11-5
Interior Shading and Shutters



External Shades and Shutters

Exterior window shading treatments are effective cooling measures because they block both direct and indirect sunlight outside of the home. Solar shade screens are an excellent exterior shading product with a thick weave that blocks up to 70 percent of all incoming sunlight. The screens absorb sunlight so they should be used on the exterior of the windows. From outside, they look slightly darker than regular screening, but from the inside many people do not detect a difference. Most products also serve as insect screening and come in several colors. They should be removed in winter to allow full sunlight through the windows. More expensive alternatives to the fiberglass shade screen are thin, louvered metal screens that block sunlight, but still allow a view from inside to outside.

Hinged decorative exterior shutters which close over the windows are also excellent shading options. However, they obscure the view, block daylight completely, may be expensive, are subject to wear and tear and may be difficult for many households to operate on a daily basis. They work best in hot, sunny climates, when they can be closed for weeks at a time.

Interior Shades and Shutters

Shutters and shades located inside the house include curtains, roll-down shades, and Venetian blinds. More sophisticated devices such as shades that slide over the windows on a track and interior movable insulation are also available. Figure 11-5 pictures several interior shading devices.

Interior shutters and shades are generally the least effective shading measures because they try to block sunlight that has already entered the room. However, if passive solar windows do not have exterior shading, use interior measures. The most effective interior treatments are solid shades with a reflective surface facing outside. In fact, simple white roller blinds keep the house cooler than more expensive louvered blinds, which do not provide a solid surface and allow trapped heat to migrate between the blinds into the house.

Table 11-2
Shading Design Strategies

Window Direction	Landscaping	Overhangs	Shade Screens	Interior Shades	Recommended Strategies
South	Even deciduous trees shade some in winter. Provide a few high branching trees. Use shrubs and ground cover to reduce sunlight reflected into windows from the ground.	They do not shade diffuse sunlight on hazy days and ground- reflected sunlight, two of the most important sources of summer solar heat gain.	Block up to 70% of sunlight before it gets through window. Can be very effective.	Can eliminate over 40% of solar gains. Should be used on all windows without exterior shade screens. Roller blinds are more effective than Venetian blinds.	Shrubs & ground cover. 1-1/2 to 2-1/2 foot overhang that does not block winter sunlight. Also use shade screens or interior shades.
Southeast & Southwest	High branching trees are appropriate near southeast and southwest corners of house.	Even less effective than on south windows.	Effective.	Effective.	High branching trees. Shrubs and ground cover. Also use shade screens or interior shades.
East & West; Northeast & Northwest	Low branching trees block low morning and afternoon sun. Shrubs next to the house are less effective, but shade ground-reflected sunlight.	Must be as long as the window is tall (e.g. porches and carports) or use awnings that extend over windows.	Effective.	Effective.	Low branching trees. Ground cover. Also use shade screens or interior shades.
North	Evergreen trees provide summer shading (north windows do get some summer sun) and serve as a wind break.	Ineffective.	Effective if incoming sunlight is a problem.	Can help control the small amount of incoming sunlight.	Evergreen trees. Also consider interior shades.

Table 11-3
Solar Heat Gain Coefficients for Window Coverings

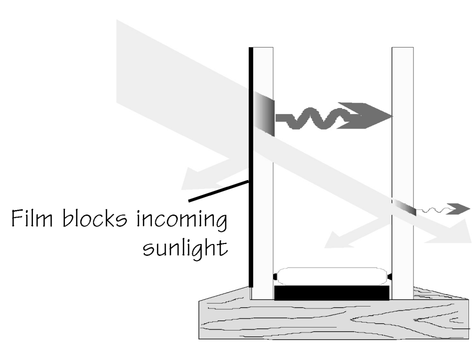
Type of Covering	Shading Coefficient*
None	0.88
Medium-colored venetian blinds	0.57
Opaque dark shades	0.60
Opaque white shades	0.25
Translucent light shades	0.37
Open weave dark draperies	0.62
Close weave light draperies	0.45

*Lower numbers shade better. The table assumes windows are double-glazed. Source: ASHRAE Handbook of Fundamentals, 1985.

Reflective Films and Tints

Reflective film, which adheres to glass and is found often in commercial buildings, can block up to 85% of incoming sunlight. The film blocks sunlight all year, so it is inappropriate on south windows in passive solar homes. However, it may be practical for unshaded east

Figure 11-6
Reflective Window Film



and west windows. These films are not recommended for windows that experience partial shading because they absorb sunlight and heat the glass unevenly. The uneven heating of windows may break the glass or ruin the seal between double-glazed units.

The installed cost of reflective films ranges from $1 to $4 per square foot. Price should not be the sole criterion when selecting an installer — quality is a vital consideration affecting the appearance of the house and the beauty of the view to the outside.

Most window manufacturers offer tinted windows, which can have Solar Heat Gain Coefficients under 0.30. The window tints add color, such as green, amber, rose, blue, or a reflective finish to the window. These tints are often inexpensive, costing only $3 to 10 extra per window for many units. However, the tint is permanent, so incoming sunlight will be blocked in both summer and winter.

VENTILATION

Cooling ventilation measures not only help improve comfort, but also bring in fresh air. Air movement increases comfort by evaporating moisture from the skin. Research has shown that people feel as comfortable in rooms at 85°F with air movement as in rooms at 75°F with still air. Both natural ventilation and mechanical ventilation measures can be important for low cost cooling.

Natural Ventilation

Summer breezes can generate air movement inside the house. All rooms used frequently should be designed for ventilation from the wind; however, natural breezes are unpredictable throughout most of Louisiana. They usually do not blow from any one direction reliably in spring, summer, or fall and are not very strong. Do not rely on the wind as the only source of air movement.

Another form of natural ventilation is called the *stack effect*. As shown in Figure 11-8, hot air can exit the house through a high opening. A low opening lets in outside air to replace the exiting air. The stack effect is also not a reliable form of ventilation, particularly on hot days when the outside air drawn into the house is uncomfortable.

However, the stack effect can keep rooms with high ceilings more comfortable than today's standard homes

Figure 11-7
Natural Ventilation Design Strategies

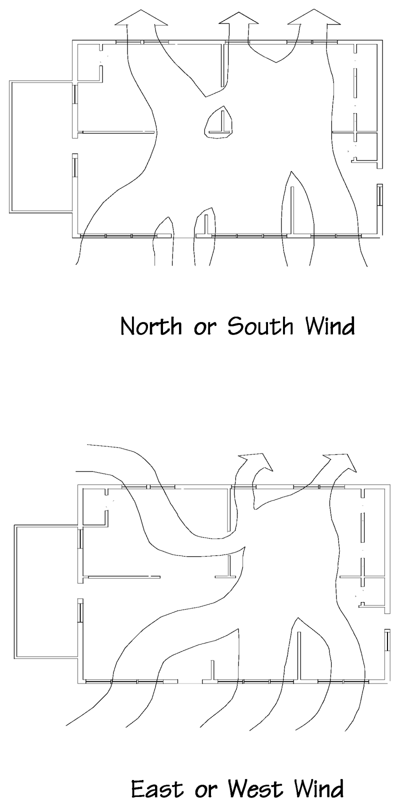


Figure 11-8
The Stack Effect

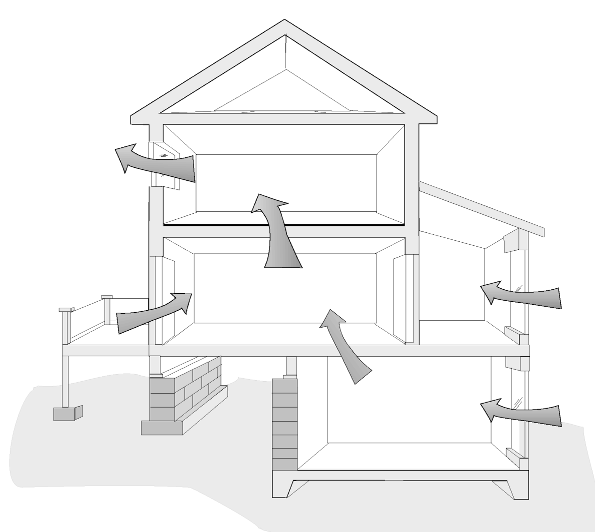


Table 11-5
Comparative Power and Operating Costs of Cooling Equipment

Type of Equipment	Air Flow (cfm)	Typical Electricity Cost (¢/hour @ 8¢/kwh)
Portable fan	1,500 - 2,500	0.5
Ceiling fan	1,000 - 7,000	2.0
Whole house fan	3,000 - 12,000	3.0
Room air conditioner	n/a	16.0
Central air conditioner	n/a	29.0

with 8-foot ceilings. In rooms with 10- or 12-foot ceilings, air temperatures near the floor may be 5 to 10 degrees cooler than those near the ceiling.

Mechanical Ventilation

Mechanical ventilation—using fans or blowers—provides an inexpensive means of creating a cooling air flow. Air movement across the skin causes more rapid evaporation and consequent cooling.

Internal air movement created by portable fans or ceiling fans can provide comfort inexpensively. Use interior fans even when the air conditioning is operating. For each degree that the thermostat is raised, air conditioning costs drop 3 to 8 percent. By setting the thermostat between 80 and 85°F and using fans that blow directly on room occupants, homeowners can save 20 to 50 percent on cooling bills. Sizing rules for ceiling fans are shown in Table 11-4.

Whole house fans, also called attic fans, blow hot room air from inside up into the attic and pull supply air into the home from outside. Table 11-5 shows that whole house fans are more powerful than ceiling fans, but are still economical to operate.

The primary disadvantage of whole house fans is that they bring in outside air containing moisture, dust, and, at times, pollen and other allergens. However, for most people, whole house fans can save on cooling bills, especially in spring, early summer, and fall. In fact, many homes without air conditioning rely solely on whole house fans to maintain comfort.

Guidelines for sizing whole house fans are summarized in Table 11-6. They can be coupled with ceiling fans to reduce cooling costs 30 to 60 percent as follows:

- ❒ When it is hotter than 85°F outside, set the air conditioner thermostat at 85°F and run ceiling and portable fans
- ❒ When it is cooler than 85°F outside and not excessively humid, turn the air conditioner off, open windows, and run the whole house fan It is best to operate the air conditioning system during

Table 11-4
Sizing Rules for Ceiling Fans

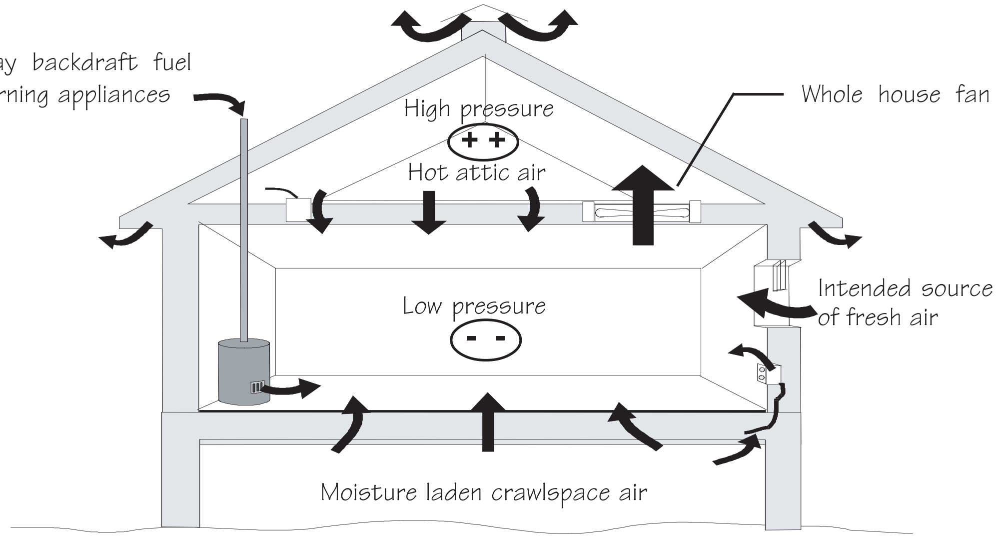
Largest Room Dimension	Minimum Fan Blade Diameter (inches)
12 feet or less	36
12 to 16 feet	48
16 to 17-1/2	52
17-1/2 to 18-1/2	56
18-1/2 or more feet	2 fans

Table 11-6
Sizing Rules for Whole House Fans

Size of House (sq ft)	Size of Fan Needed (cfm)
1,000	4,000 - 8,000
1,500	6,000 - 12,000
2,000	8,000 - 16,000

*The fan should provide 0.5 to 1 air change per minute, This means the volume of air in the house is blown outside one to two times every two minutes; a 2,000 sq ft house with 8-foot ceilings has a volume of 16,000 cubic feet, so it requires a whole house fan that can move 8,000 to 16,000 cubic feet of air per minute (cfm).

Figure 11-9
Whole House Fans in Leaky Homes



humid weather to provide dehumidification. A central dehumidification system, discussed later, could also be considered

- ❒ On days when temperatures do not rise above 85°F until mid or late afternoon, try ventilating during the cooler morning hours. As temperatures increase, close windows and pull shades to keep the heat outside. Use interior fans to create a breeze. As temperatures cool in the evening, open the house and ventilate

Whole house fans are primarily recommended for houses without air conditioning or for homes whose occupants are committed to saving energy and are willing to operate their home carefully.

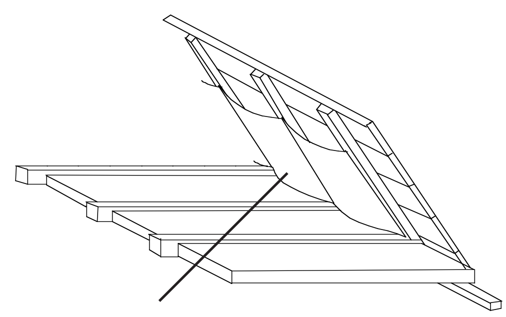
Homes that use whole house fans, such as the example in Figure 11-9, need several other features:

- ❒ Adequate attic ventilation to exhaust the large volumes of air blown into the attic effectively
- ❒ A well sealed pressure boundary between the crawlspace, home, and the attic. If there is air leakage between the home and the attic, the consequences can be severe. The attic air and damp crawlspace or basement air will leak into the home, increasing temperature and humidity and decreasing comfort
- ❒ No combustion appliances that operate when the whole house fan is turned on should be inside the pressure boundary or backdrafting may occur. Negative impacts could include carbon monoxide entering the home or flame rollout — where the outside air being drawn down the flue pushes the flame for the appliance into the room

Radiant Heat Barriers

On a sunny summer day, the temperature of a home's roof can climb above 160°F. As the roof gets hot, its heat moves across the attic air space in the form of long-wave radiation. When this heat strikes the attic insulation, it warms the top surface and causes more heat to be conducted into the house, thus driving up cooling bills. Much of this radiant heat can be blocked using reflective materials called *radiant heat barriers.*

Figure 11-10
Radiant Heat Barrier



Radiant barriers work in two ways. They reflect the radiation that strikes their surface, and they do not readily emit heat. To be effective, the shiny side must face an air space and the air space should be vented to the outside. Continuous ridge and soffit vents usually provide enough ventilation.

Some roofing manufacturers and builders have expressed concern about roof temperatures being higher in homes with radiant heat barriers, thus decreasing the life of the roof deck and the shingles. According to research conducted by the Florida Solar Energy Center and Oak Ridge National Lab (ORNL), radiant heat barriers increase roof temperatures no more than 10°F.

The reflective surface must also remain dust-free. A recent study showed that after four years, the effectiveness of radiant heat barriers installed on top of the attic floor insulation had declined about 50% due to dust accumulation. Therefore, a radiant barrier should be installed with its shiny side facing down to minimize lowered effectiveness due to dust settling on its surface. Generally, radiant barriers are stapled to the underside of the rafters in an attic. While they can be placed on top of the attic floor insulation, most experts feel that dust will accumulate on the reflective surface at this location.

According to research conducted in the southeastern United States, radiant heat barriers can reduce cooling costs 5 to 20 percent for some homes. Actual savings depend on many factors, including climatic conditions, the amount of roof shading, the level of attic insulation and ventilation, and the location of the radiant barrier.

Table 11-7
Radiant Heat Barrier (RHB) Performance

Construction	Annual Energy Bills: Heating	Annual Energy Bills: Cooling
Attic Applications		
Standard R-11, no RHB	$396	$553
Standard R-19, no RHB	372	531
Standard R-30, no RHB	359	519
RHB with R-11	396	519
RHB with R-19	372	507
RHB with R-30	359	503

Modeled for a 2,000 sq ft attic in Baton Rouge, LA using REM-Rate version 8.3 software.

The different radiant heat barrier products available (even those with air bubbles or several layers of foil) vary little in performance.

Radiant heat barriers are never a substitute for insulation. Ceiling insulating values of at least R-19 are recommended before considering radiant heat barriers. These products have been oversold by zealous sales personnel who have made misleading claims. Prices vary substantially — from under $0.10 per square foot to over $0.70 — so shop wisely.

Multiple layers of radiant barrier material are not generally cost effective. The first barrier surface eliminates about 95% of the radiant heat transfer across the attic. Adding more can affect only 95% of the remaining 5%.

Reflective barriers are recommended in east and west walls by the Florida Solar Energy Center in southern Louisiana. The walls should be unvented and located in climates with very low demand for heating in winter. Multiple layers of barrier materials work better in walls than in attics.

Reflective Roof Coatings

An additional way to reduce attic and roof temperatures is through reflective roof coatings. Traditional dark or medium colored roofing materials can absorb 70% to 90% of the sunlight that strikes them. Light-colored coatings applied to the surface of your roof can reduce this absorption up to 60% as well as provide additional waterproofing. Field tests on various roof types performed by the Florida Solar Energy Center indicate savings on cooling bills of 19% on average.

White coatings are the most effective due to their superior reflective and re-emitting properties and are available at many local building supply outlets. The most effective locations for reflective coatings are roofs with lower insulation levels that receive harsh sunlight.

Due to the relatively high cost of materials ($0.06 - $0.12 per square foot), coatings are most economical if applied to new homes or when replacing an existing roof . When the coating is applied to a fresh roof, the homeowner can take full advantage of its reflective, waterproofing, and roof preservation qualities over the entire life of the roof. If care is taken to keep the coating free of dirt and algae stains, degradation of the reflective qualities will be minimal, but if unattended, substantial degradation can occur.

Moisture Control

Energy efficient homes in Louisiana have a substantial need for dehumidification. In warm and hot weather, 20% to 40% of the energy used by the air conditioning system goes to remove moisture. By using moisture control strategies during construction (see Chapter 1 for a set of drawings which include moisture control tips and Chapter 2 for moisture control concepts), you can reduce the dehumidification load.

There are mechanical devices whose goal is to dehumidify the air. They can often make homes comfortable at relatively warm indoor temperatures. While not a full substitute for air conditioning, the following systems can often reduce cooling bills:

Central Dehumidification Systems

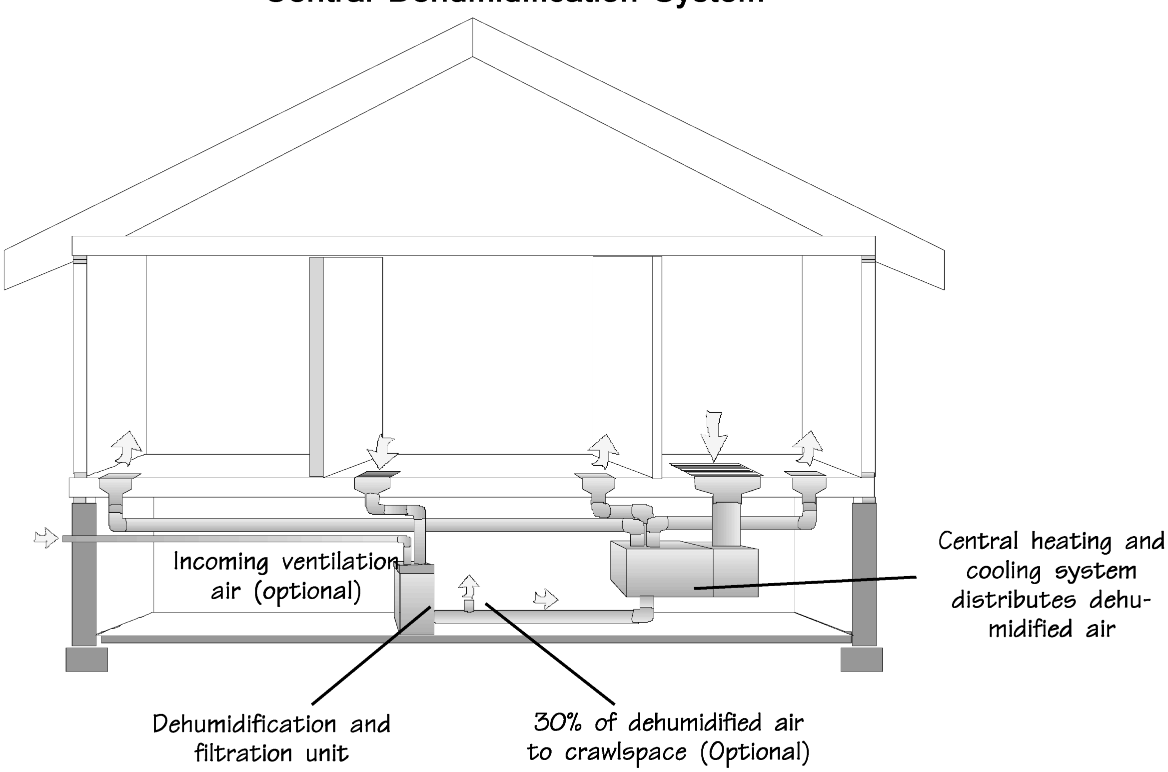
Several manufacturers are marketing central dehumidification systems designed to provide comfort during warm weather. In hot weather, they can supplement the central air conditioning system and allow comfort at higher indoor thermostat settings.

A schematic for a typical system is shown in Figure 11-11. The system can be controlled by a dehumidistat, which senses the relative humidity of the room in which it is located. While not a substitute for air conditioning in most of Louisiana, dehumidification systems can provide comfort during much of the year, work well in conjunction with central cooling systems, and may handle all of the summer comfort needs in downstairs rooms that are well insulated and have limited window area.

Desiccant Cooling Systems

Considerable research has investigated different approaches for using these materials which absorb moisture from the air to reduce cooling loads. Desiccants such as Lithium Chloride (LiCl) or Silica gel have a high attraction for water vapor, making them excellent materials for removing moisture from humid air. As shown in Figure 11-12, some desiccant systems have a ceramic wheel impregnated with the desiccant material. The incoming airstream gives up its moisture to the desiccant and continues on to the air conditioner to be cooled.

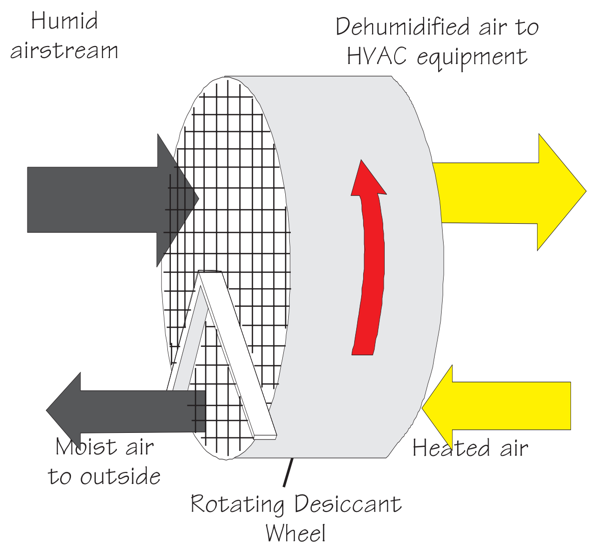
Figure 11-11
Central Dehumidification System



The humidity-laden wheel rotates into a smaller airstream where it releases its moisture to air that has been heated by either solar energy, waste heat, or gas. In this way the desiccant is continuously regenerated (dried), with dry desiccant always moving into the process airstream. Other systems use liquid desiccants instead of a desiccant wheel to remove moisture, but utilize similar methods to regenerate the desiccant material. According to some estimates, desiccant cooling could reduce a building's total electricity demand by as much as 25% .

There are additional benefits of desiccant systems. They may allow HVAC contractors to reduce compressor size due to reduced latent cooling loads and will improve indoor air quality by maintaining a lower ambient relative humidity.

Figure 11-12
Desiccant Wheel Dehumidifier



ALTERNATIVE COOLING OPTIONS

In addition to ventilation and shading, numerous other options have been considered to help provide comfort in summer. These alternative cooling techniques reduce temperatures by transferring heat and moisture to the earth or the air.

Unfortunately, the high humidity levels and warm nights that are prevalent in the South limit the effectiveness of most of these alternatives. In arid climates with hot days and cool, dry nights, such as in the southwestern United States, these measures work better. They are summarized below:

- **Evaporative Cooling** — Use evaporating water to cool surfaces such as swamp coolers or roof spray systems
- **Solar Chimneys** — Solar collectors located on the roof can generate very high air temperatures. If the hot air is allowed to rise and escape from the top of the collector, it creates a natural draft that can pull in air from the home. Thus, solar chimneys function like solar-powered whole house fans; however, they cannot pull air at high velocity, which is one of the primary cooling functions of a large, whole house fan. Most systems use 200 to 350 square feet of collector, which would cost over $2,000 — a sizable investment with no prospect for a positive rate of return
- **Earth Cooling Tubes** — A number of homes have used pipes buried several feet underground to cool outside air drawn into the home. Some designs circulate room air through a closed-loop system rather than drawing outside air. Their performance in the Southeast has been disappointing. Little cooling or dehumidification has been reported for the few systems that have been monitored. Installation of the tubes can be expensive and requires digging up the site. A 500-foot tube costing several thousand dollars may save up to $75 annually, while providing little or no dehumidification

Earth cooling tubes are not recommended as a practical natural cooling method. Geothermal heat pumps, which circulate water in tubes located below grade, are a more practical alternative.

Notes: